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THE RELATION OF ELECTRICAL ENGINEERING TO OTHER PROFESSIONS[1]

ON the wall of a great engineering library is the legend "Engineering is the art of organizing and directing men, and of controlling the forces and materials of nature for the benefit of the human race." This is broad and all-embracing, but other professions will find it hard successfully to quarrel with it. While the immediate object of engineering is a material one, engineers draw from many different channels of human energy, such as generalship, commerce, psychology, mechanics, economics, to say nothing of chemistry and physics and many others, all under an interpretation, insight and method that are best described by the term scientific.

It may be asked, Why could not a similar statement of embrasure or scope apply to medicine, the law, the army and other professions? In part it could, but it is to engineering that it applies preeminently. The subject-matter of the older professions, the things about which they busy themselves, and the objects they seek to accomplish have changed relatively little in many centuries. The means have altered but the ends persist. They are approximately the same to-day as they have been throughout history and tradition. With engineering it is different. There was no such profession a hundred and fifty years ago, and if I may a little anticipate my conclusion, there will be no such profession a hundred and fifty years hence in respect to a large part of what we now call engineering.

[1] President's address presented at the twenty-ninth annual convention of the American Institute of Electrical Engineers, Boston, Mass., June 25, 1912.

Such as it is, engineering is embracing an ever-growing horizon, and is including more and more of the activities of civilization. When I say activities I refer to material ones and not to the whole of life itself. The human spirit is the greatest fact in the world, and art and literature that interpret it, the acts of our daily life and our personal relations that depend upon it, religion and the vast body of our social and political experience, that go to constitute life form undoubtedly a mass of activities, which are greater, in terms of consciousness, than the material activities which engineering can affect. In other words, the humanities which have been the same for ages can never be invaded by anything that merely rearranges our relations to the material world.

In the material world, however, which is at once the workshop and the throne, the glory and the limitation of the engineer, marvel has followed marvel and shall be followed by more marvels, for we are beginning to catch the tools' true play; beginning to see the vision of our dominion over the earth. Whether it really is engineering to organize men, to predict the psychology of a fare-paying population, to win the endorsement of a labor union, to treble the yield of a farm by a microscope, all of which successes to-day are called engineering, depends upon the definition that we finally adopt.

It is startling to study the variety and importance of the posts filled by engineers and to note the range of what they do. From the efficiency engineer presenting surprises in the output of a factory where the human factor is large, or the industrial engineer suddenly after thousands of years showing the world how to increase greatly the lay of bricks, or the agricultural engineer working miracles with the soil that for ages farmers have struggled with, to the civil engineer establishing a kingdom and building the Panama Canal, we have instances in which the engineer is doing more and more of the world's work.

The history of this class of men so rapidly growing in numbers, so rapidly differentiating in function is almost a romance. The "Encyclopedia Britannica" names the middle of the eighteenth century—that is, 1750—as the time before which there were only military engineers—who constructed "engines" of war—and it adds that at about that time there began to arise a new class. Little did this new class realize the army it was leading down the industrial paths of time!

The "new class" has surpassed all bounds. From insignificance a hundred and fifty years ago it has increased almost incredibly in numbers and variety of specialization. As a local indication, the Engineering Societies' Building in New York is the headquarters of fifty thousand engineers. As another local indication, the American Institute of Electrical Engineers has in the last ten years increased six fold. The growth in the variety of specialization has been almost as rapid as the increase in numbers. Where there were only military engineers and the "new class" a hundred and fifty years ago, there are twenty-seven recognized varieties to-day. Without mentioning all, they range from civil through mechanical, electrical, mining, illuminating and chemical, to refrigerating, industrial, agricultural and aeronautical. There is even a magazine with the title *Human Engineering*.

A large and increasing part of the capacity of our colleges and universities is devoted to the education of engineers. Parts of the engineering curricula are borrowed for what used to be purely classical courses. The metaphors of the speech of the day often have an engineering basis

and—we have a McAndrews hymn. The man in the street knows something about spark plugs, and many women understand the general principles of the telephone. The social status of the engineer has emerged from that of a mechanic to one nearly as high as that of the clergyman, the physician or the lawyer.

Relatively recently there has been going on simultaneously with all this, however, hardly noticed, something else—a vast increase in so-called engineering work by men who are not engineers, and at the same time a large drawing off into executive, administrative, industrial, commercial, civic, educational, financial and even legal callings, of men of engineering training. A history of segregation and disintegration seems to have begun to accompany a history of integration and building up.

For one to say to-day he is an engineer gives very little idea of what he actually does. It does not locate him in one of the twenty-seven recognized classes. It leaves it possible for the hearer to think of him as a "social engineer" or an "efficiency engineer" should he not look like a "civil engineer"; but even if he did define himself and say he was an electrical engineer, the hearer would still not know whether he represented the last word on the loading of telephone circuits or his responsibility was to determine whether the great railroad terminals of Chicago should use a third rail or an overhead catenary. If he should say "I am a teacher," "a physician," "a clergyman," "a lawyer," there would be a much more definite conception attaching to his answer. There must be, therefore, in the title "engineer" something broader, something not included, or included to a lesser degree, in the titles of the other professions or occupations.

A light is shed if we examine the popular definition that engineering is "educated common sense." Can it be that unlike "physician," "lawyer," "teacher," the term "engineer" does not describe what a man *does,* but rather *how* he does it! A method rather than an occupation! It is even so; that is, essentially and with limitations I shall refer to later.

What then is this "method" that has given the engineer his ever broadening domain and brought all kinds of men and callings to his school? He can tell you at once. Here is where he is defined and where his fellows recognize him and each other though they come from the ends of the industrial earth as to diversity of actual occupation. The method had its birth in Greece, though it was stifled almost to death by the tremendous philosophic, humanistic and artistic energies of the Hellenes. Later it was buried in Europe under the irruption of the barbarians. The names of Thales, dear to our profession, with his "elektron," and of Aristotle and Archimedes, stand out as having done much for it—especially Archimedes—in spite of the humanistically polarized intellectual atmosphere in which they lived and which they contributed so gloriously to create.

But the Greeks made only a start. To quote an authority, their material thinking was largely based on what has proved to be a wrong method of procedure, the introspective and conjectural rather than the inductive and experimental. They investigated nature by studying their own minds, by considering the meanings of words, rather than by studying things and recording phenomena. But they saw much of the light with all this. Though absolutely dead for a thousand years in Europe, "the method" was kept alive during the middle ages in Arabia, although confused with magic, alchemy and algebra. Then came Roger Bacon, Leonardo da Vinci and

Copernicus, and science as we know it began to take shape.

Aristotle had sat down in his chamber and he wrote in a book, "A body twice as heavy as another of course falls twice as fast." Galileo released simultaneously from the top of the Leaning Tower a one-pound and a one-hundred-pound shot and they reached the earth together, before the eyes of the assembled University of Pisa. But "the method" was repugnant to the university, and almost to a man they believed their Aristotle, sophistically explained away what they saw, and persecuted Galileo. Descartes, Newton, Lagrange, Laplace, Francis Bacon connote to engineers the transcendent story, unless for electrical engineers there should be added Ampère, Faraday, Henry, Helmholtz, Kelvin.

The method of doing things that makes an engineer is, therefore, the applying to practical and utilitarian ends the principles and reasoning of science. Engineering is not science, for in science there is no place for the conception of utility. Truth is her sole criterion. In the exalted language of Professor Keyser, "Not in the ground of need, not in bent and painful toil but in the deep-centered play-instinct of the world science has her origin and root; and her spirit, which is the spirit of genius in moments of elevation, is but a sublimated form of play, the austere and lofty analogue of the kitten playing with the entangled skein or of the eaglet sporting with the mountain winds."

Engineering is science's handmaid following after her in honor and affection, but doing the practical chores of life, concerned with the useful and the material; with costs and with expediency, and concerned with the humanities only in so far as they are an incident in some particular scheme of reality, and then objectively, if that may be said. Her methods merely apply straight thinking to material problems for useful purposes.

Does this constitute a profession? No. Some day it will be the way almost everybody thinks instead of a body of specialists and then the difference between a doctor, for instance, and an engineer, will be only in the things they busy themselves about; as is to-day the only difference between kinds of engineers.

The center of education has been shifting rapidly recently—almost as rapidly as material well being has been increasing. The application of science to living has marked an age as distinct as the age of the climax of art in Greece. The "new class" has been but a pioneer in sowing the seeds of scientific rationalization in a field the value of which was only dreamed of by Archimedes and not actually recognized until, as the encyclopedia tells us, "about the middle of the eighteenth century," when the "new class" began to arise. And now, as to the limits within which engineering is a method rather than an occupation.

There will always be engineers, for the methods of science will constantly advance, and there will be needed continually, to interpret and transmit them to mankind, and to make the first applications of them to useful purposes, a class of men who, by instinct and taste, as well as by the possession of what I later shall call the dynamic component, find easier than other men—and consequently perform better—the kind of scientific thinking, observation and action that characterize engineers to-day.

What these men will be busy about it is hardly safe to say, although it is probable the present great divisions of engineering will be more or less preserved. It seems certain that a large mass of knowledge that now is called engineering and forms the basis of many of the engineering spe-

cializations, will become general knowledge, and will be absorbed by the community, partly as a result of the shifting of the center of education and partly through every-day familiarity, and the men possessing this knowledge will no longer be called engineers. They will be called farmers, let us say, in the case of the "agricultural engineer"—of course, a farmer of a very advanced kind compared to the earlier one.

But the center of education will not always continue to shift. It is shifting now only because it has so long been eccentric. It would be a calamity for it to shift too far, resulting in a world whose sole training was applied science and the utilities. Under such a condition, engineering and the utilities themselves would languish instead of flourishing, for there would be lacking in engineers the dynamic component.

Ample knowledge, insight, information does not make an engineer. He must first be a man. Engineering is not thought like philosophy; it is thought times action, and only when the qualities of action are developed approximately to the same extent as the qualities of thought is an engineer at his best. Only then is his area of effect a maximum. The qualities of action involve tastes and personality, the feelings, the will. And it is these that constitute the component or factor that makes an engineer's intellectual or rationalizing equipment dynamic—that puts it to use.

It was partly the intense appreciation of the value of the dynamic component that led the Greeks and successive centuries astray in the direction of their education and contributed to an underestimate of the importance of science and the study of the laws of nature. We must not go to the equally wrong other extreme.

So far I have said but little of electrical engineering. It must be brought in if for no other purpose than to justify our title. Although the article on "Engineering" in the "Britannica" occupies only six inches of one column, it concludes with the following: "The last great new branch is *electrical* engineering, which touches the older branches at so many points that it has been said that all engineers must be electricians." If engineering is a method of doing things, and electrical engineering tends to embrace all other branches, there is an implication that electrical engineering is the latest or most highly developed form of the method—the method that is the utilitarian application of the principles of science to the material facts of life.

Such is unquestionably the case. Born scarcely more than twenty-five years ago, the "youngest branch," electrical engineering, had the opportunity of striking its roots into the richest of scientific soils, free from prejudices, customs or traditions. It had no entangling alliances, no political laws to retard or encumber it. The field it preempted was the terra nova of engineering, the new world of applied science.

Under the influence of those geniuses of science, Volta, Faraday, Ampère, Ohm, Kelvin, Helmholtz, Maxwell, Oersted, Henry, and with the metric system for its cornerstone, there developed a comprehensive structure of thought and a related scheme of units. The latter are the admiration of the world for their simplicity, their convenience, their precision and their reproducibility. The scientific method as applying to all phenomena acquired its most perfect embodiment in the electric system and its relations.

But there is a philosophical debt that we electrical engineers owe our units. They school our minds. The ability to measure with precision difficult and complicated quantities enables clear thinking on them and renders reasoning about them possible

that otherwise could not be attempted. To name a thing is to know it. The wonderful electrical units are a fluent language that gives the widest opportunity to thought. By their character they educate our faculties of definition and of relation. They typify all quantitative thinking, not merely electrical. They are the epitome, the last word of the great minds of our age, as to what the scientific method of thought is, in relation to the whole realm of matter and force.

Therefore although the subject matter of electrical engineering is covering a wider and wider range—so wide as to be almost incongruous—the electrical method of thinking is applicable throughout. It is spreading far beyond. As an electrical engineer, I even find myself thinking of the crowds passing in the streets in terms of amperes and volts, and of the fluctuations of the stock market in terms of current, inductance, capacity, resistance and resonance.

That which can impose form upon our thought enables us successfully to think of any kind of thing. The forms of thought established for electrical engineering are at once so comprehensive, so rigid, so rich in detail, and so illuminating that engineering does not bound them. They may be called the manifestation of science in civilization, the best representation of the scientific method at work for utilitarian ends. They prove that the profession of electrical engineering not only deals with single-phase motors, storage batteries, high-tension transmissions, turbo generators, coronas, carbon transmitters and commutation, *as an occupation,* but that it also is a *way of thinking,* and as such is not an occupation, but the latest and most highly developed scientific method of solving all kinds of practical problems of matter and force, for the benefit of the human race.

Gano Dunn

HONORARY DEGREES AT THE UNIVERSITY OF MICHIGAN

On the occasion of the celebration of the seventy-fifth anniversary of the University of Michigan honorary degrees were conferred by vote of the senate council and board of regents on graduates of the university and former members of the university senate. The doctorates conferred on scientific men with the accompanying remarks were as follows:

THE DEGREE OF DOCTOR OF SCIENCE

Edward Allen Fay, of the class of 1862, educator, editor, one of the foremost Dante scholars in this country and historian of American schools for the deaf.

Doctor John Elmer Weeks, of the class of 1881, department of medicine and surgery, now professor of ophthalmology in New York and Bellevue University, joint discoverer of the Koch-Weeks bacillus.

Doctor John Jacob Abel, of the class of 1883, professor of materia medica and therapeutics in the department of medicine and surgery of this university from 1891 to 1893, now professor of pharmacology in Johns Hopkins University, distinguished for his researches and original contributions.

Doctor Henry Sewall, professor of physiology in this university from 1882 to 1889, now professor of physiology in the University of Colorado, whose research on immunization to the venom of the rattlesnake done while a professor in this university laid the foundation for the discovery of diphtheria antitoxin.

Bryant Walker, of the class of 1876, a man who, though a busy lawyer, has found the time to make himself well and favorably known for his published work on molluscs, a world authority on the group.

Charles Francis Brush, of the class of 1869, department of engineering, the earliest pioneer in the field of electric lighting, inventor of modern arc electric lighting, honored many times at home and abroad for his scientific achievements.

THE DEGREE OF DOCTOR OF ENGINEERING

George Henry Benzenberg, of the class of 1867, department of engineering, past president of the American Society of Civil Engineers, a noted authority on the construction of water works, distinguished civil engineer and citizen.

Cornelius Donovan, of the class of 1872, depart-